MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2019/2020

PPH0135 – ELECTRICITY AND MAGNETISM

(Foundation in Engineering)

14 OCTOBER 2019
2.30 p.m. – 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 6 pages excluding cover page with 5 questions only.

2. Attempt ALL questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Consider an electrically neutral object. If this object is given a negative charge, does its mass increase, decrease, or stay the same? Explain. [1 mark]

(b)(i) State Coulomb's Law. [1 mark]

(ii) Three charges $q_1 = q_2 = +3.0\ \mu C$ and $q_3 = -3.0\ \mu C$ are placed at the three corners of a square as shown in Figure Q1. Determine the resultant electrostatics force that acts on q_3 due to q_1 and q_2. [4 marks]

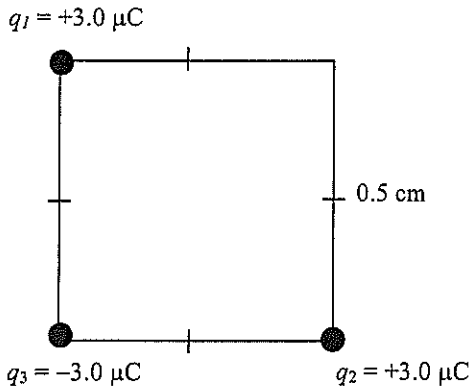

Figure Q1

(c)(i) A computer monitor accelerates electrons and directs them to the screen in order to create an image. If the accelerating plates are 1.3 cm apart, and have a potential difference of 25,000 V, what is the magnitude of the uniform electric field between them? [2 marks]

(ii) We say that a capacitor stores charge, yet the total charge in a capacitor is zero; that is, $Q + (-Q) = 0$. In what sense does a capacitor store charge if the net charge within it is zero? [2 marks]

Continued.....

Question 2

(a)(i) List two factors that affect the resistance of a conductor. [2 marks]

(ii) A 1.45 m cylindrical rod of radius 0.25 cm is connected to a power supply that maintains a constant potential difference of 15.0 V across its ends, while an ammeter measures the current through it. The ammeter reads 18.5 A at 20.0 °C. Thermal expansion of the rod is negligible. Find resistance and the resistivity of cylindrical rod at 20.0°C. [1 + 2 marks]

(b) State the Kirchhoff's Current Law and Kirchhoff's Voltage Law. [2 marks]

(c) A typical circuit is shown in Figure Q2.

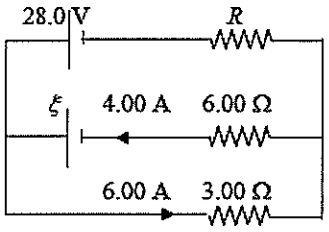

Figure Q2

Find:

(i) The unknown e.m.f., ξ. [2 marks]

(ii) The current flows through the resistor R. [1 mark]

Continued.....

Question 3

(a) A 2×10^{-19} C positive charged particle is moving in a circular orbit of radius 14 cm in a uniform 0.4 T magnetic field perpendicular to the velocity of the charged particle.

(i) Calculate the speed of the charge particle if it has a mass of 3×10^{-27} kg. [2 marks]

(ii) If a 2×10^{-19} C negative charged particle with mass of 1×10^{-27} kg moves in a direction perpendicular to the same magnetic field and having the same speed as the positive charged particle obtained in part (i), explain how the radius of the orbit due to the negative charged particle be different from that of the positive charged particle. [2 marks]

(b)(i) Describe how the motion of a charged particle can be used to distinguish between an electric and a magnetic field. [1 mark]

(ii) A current-carrying wire is placed in a region with a uniform magnetic field. The wire experiences zero magnetic force. Explain. [2 marks]

(c) A uniformly wound solenoid having 300 turns, its length is 20.0 cm and its cross-sectional area is 4.00 cm^2. The core of the solenoid is air. Determine the inductance of the solenoid. [3 marks]

Continued.....

Question 4

(a) An alternating current is described by the equation $I = I_o \sin(\omega t)$.

(i) Sketch graphs of I and I^2 on the same axes of time t. Label your graphs clearly. [2 marks]

(ii) What are the average values over a complete cycle, of I and I^2? [2 marks]

(b) Figure Q4 shows a circuit consists of a 200 Ω resistor, a 0.400 H inductor, a 6.00 μF capacitor and an alternating voltage source that has r.m.s. voltage of 20.0 V and a frequency of 40.0 Hz.

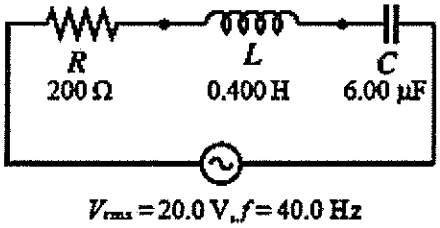

Figure Q4

Find:

(i) The total impedance of the circuit. [1 mark]

(ii) The r.m.s. current flowing in the circuit. [1 mark]

(iii) The r.m.s. voltage drops across the resistor, inductor and capacitor. [1 mark]

(iv) The phase angle of the voltage source with respect to the current. [1 mark]

(v) Whether the voltage source lags or leads the current. [1 mark]

(vi) The average power dissipated in the circuit. [1 mark]

Continued.....

Question 5

(a)(i) How much are the barrier voltages, V_b for the Germanium (Ge) and Silicon (Si) type of semiconductors? [1 mark]

(ii) Differentiate the current conduction processes in metal and semiconductor. [2 marks]

(b) Discuss the characteristic of the current-voltage of a *p-n* junction when the positive and negative terminals of a battery are respectively connected to the *p-type* and *n-type* material of the *p-n* junction. [2 marks]

(c) A germanium bipolar-junction transistor (BJT) is shown in Figure Q5. The transistor is used as an amplifier for voltage amplification. Other circuit parameters are given in table below.

Parameter	*Value*
Voltage at base with respect to emitter terminal, V_{BE}	0.3 V
Direct current bias voltage between collector-emitter loop, V_{CC}	50 V
Direct current bias voltage between base-emitter loop, V_{BB}	25 V
Collector resistor, R_C	50 Ω
Base resistor, R_B	6 kΩ

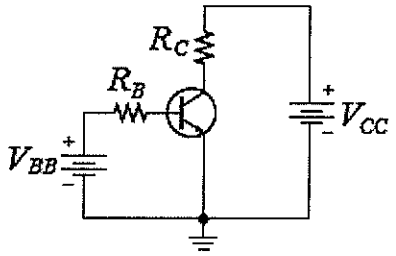

Figure Q5

(i) What is the configuration of the transistor used in Figure Q5? [1 mark]

If the direct current gain of the transistor is $\beta_{dc} = 50$, solve for,

(ii) The base current, I_B. [1 mark]

(iii) The collector current, I_C. [1 mark]

(iv) The voltage at collector respect to emitter, V_{CE}. [1 mark]

(v) The voltage at collector respect to base, V_{CB}. [1 mark]

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List of Physical Constants

Electronic charge, $e = 1.6 \times 10^{-19}$ C

Permittivity of free space (vacuum), $\varepsilon_o = 8.85 \times 10^{-12}$ F/m

Coulomb (proportionality) constant, $k = 8.99 \times 10^{9}$ Nm^2/C^2

Permeability of free space (vacuum), $\mu_o = 4\pi \times 10^{-7}$ Tm/A

Mass of electron, $m_e = 9.11 \times 10^{-31}$ kg

Mass of proton, $m_p = 1.67 \times 10^{-27}$ kg

1 electron volt, 1 eV = 1.6×10^{-19} J

Speed of light, $c = 3.0 \times 10^{8}$ ms^{-1}

Gravitational acceleration, $g = 9.81$ ms^{-2}

Some Useful Formulas

$F = qvB\sin\theta$ $\quad$ $B = \frac{\mu_0 I}{2\pi r}$ $\quad$ $L = \frac{N\Phi_B}{I}$

$P = IV$ $\quad$ $\xi = V + Ir$ $\quad$ $I = nevA$

$X_L = 2\pi fL$ $\quad$ $I_{rms} = \frac{I_{max}}{\sqrt{2}}$ $\quad$ $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$R_{eq} = R_1 + R_2 + R_3$ $\quad$ $\Phi_B = \mathrm{BA}\cos\theta$ $\quad$ $E = \frac{Q}{4\pi\varepsilon_0 r^2}$

$v = V_{max}\sin\omega t$ $\quad$ $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$ $\quad$ $R = \frac{L}{\sigma A}$

$\alpha_{dc} = \frac{I_C}{I_E}$ $\quad$ $\oint \vec{B} \cdot \overrightarrow{dl} = \mu_o I$ $\quad$ $J = \sigma E$

$u = \frac{1}{2}\varepsilon_o E^2$ $\quad$ $\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d}$ $\quad$ $V_H = Bvd$

$F = ma$ $\quad$ $V_p = -\int_0^P \vec{E} \cdot d\vec{s}$ $\quad$ $I_1 = I_2 + I_3$

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